Development of a Cost-Effective System to Monitor Wind Turbines for Bird and Bat Collisions—Phase I: Sensor System Feasibility Study

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Contractor: University of California, Santa Cruz
Subcontractor: EDM International, Inc.
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The Issue

The recent emphasis on renewable energy has catalyzed resurgent interest in wind energy and the deployment of large-capacity wind turbines. Although wind turbines represent a positive environmental impact by reducing national dependence on fossil fuels, their use is burdened with unknowns regarding their impact on birds and bats, some of which are protected and endangered species. Bird and bat collisions with wind turbines are of increasing concern to utilities, regulatory agencies, and environmental organizations. Kills have been documented at several wind farms; however, the magnitude of the problem industry-wide is unknown.

Automated monitoring of bird and bat collisions with wind turbines would provide reliable information regarding collision incidents and potential solutions.

This lack of knowledge is largely due to the fact that there is no cost-effective means for monitoring collisions with turbine blades on a widespread basis. A sensor technology is needed to enable automated data collection. Automated blade monitoring would provide the data sets required for meaningful study, allowing better definition of the problem and informed assessment of potential solutions.

This project is envisioned as the first phase of a multi-phase effort culminating in the development of a viable, cost-effective system for remotely monitoring wind turbine collisions. There is a reasonable possibility that the sensor system may also be useful for continuous online monitoring of turbine blade health. This secondary application would be a valuable benefit, as the wind energy industry has experienced numerous blade failures due to degradation mechanisms such as vibration.

Project Description

The objective of this Phase I feasibility study was to identify relatively low-cost sensor systems that can provide long-term, reliable monitoring without significant impact on turbine operation.

Researchers identified three candidate sensor technologies for monitoring bird and bat collisions with wind turbines. Accelerometers and fiber-optic sensors were identified as possible contact sensors, i.e., sensors that need to be installed directly on the wind turbine rotor blades. Acoustic sensors (microphones) were identified as a potential non-contact sensor that would not need to be installed on the rotor blades. The three sensor technologies were evaluated on the basis of installation requirements, signal processing needs, and system cost. Installation requirements for both existing and new wind turbines were considered.

PIER Program Objectives and Anticipated Benefits for California

This project offers numerous benefits and meets the following PIER program objectives:

- **Developing cost-effective approaches to evaluating and resolving environmental effects of energy production.** An automated sensor system to monitor wind turbine collisions will enable cost-effective study of bird/bat interactions with wind turbines. Such a system will greatly advance scientific understanding of the bird/bat collision problem and enable researchers to assess the efficacy of available tools and methodologies to mitigate the problem.

- **Providing environmentally sound energy.** Identifying effective methods to mitigate wind turbine impacts on wildlife will promote deployment of wind power, a clean energy source.

Results

The acoustic emission sensor (microphone) is expected to be the most viable sensor system overall due to its ease of installation—on the turbine tower rather than directly on the rotating blades—and its low-cost, off-the-shelf components.

Accelerometers are ranked second, primarily because they must be installed on the rotor blades and require associated hardware to be mounted on the rotating rotor shaft. Only a small, lightweight accelerometer would need to be installed on each of the blades and could be installed on the inside of the hollow blades. The accelerometer-based Bird Strike Indicator (BSI) sensor previously developed by EDM International could be modified for this application, thereby minimizing development requirements.

Fiber-optic sensors are deemed the least feasible sensor system, as they have similar installation requirements as the accelerometers but use more expensive equipment. These sensors are relatively new and the associated hardware is still somewhat bulky and expensive. Custom hardware would need to be developed to make a fiber-optic system practical for installation on the rotor shaft.

Turbine operating and environmental noise (mechanical sounds, wind, rain, thunder) will be a key factor in determining the success of the acoustic emission sensor for collision detection. Rotor blade vibrations will also affect the ability of accelerometers to detect collisions.

The next phase of this project, proof-of-concept testing at the National Renewable Energy Laboratory in Golden, Colorado, will compare the sensitivity of acoustic sensors versus accelerometers in detecting collisions in the presence of turbine noise, and thus determine if acoustic sensors will perform adequately or if further development should focus on accelerometers. The final phase of the project will then design and assemble a prototype sensor system for field testing at actual wind farms.

Final Report

The final report for this project is posted on the Energy Commission's website at www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2007-004.

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